



(19)

**Europäisches Patentamt  
European Patent Office  
Office européen des brevets**



(11)

EP 0 903 190 A2

(12)

## EUROPEAN PATENT APPLICATION

(43) Date of publication:  
24.03.1999 Bulletin 1999/12

(51) Int Cl. 6: B22D 11/06

(21) Application number: 98307241.4

(22) Date of filing: 08.09.1998

(84) Designated Contracting States:  
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU  
MC NL PT SE**  
Designated Extension States:  
**AL LT LV MK RO SI**

(30) Priority: 18.09.1997 AU PO9253/97  
30.09.1997 AU PO9522/97

(71) Applicants:

- Ishikawajima-Harima Heavy Industries Co., Ltd.  
Chiyoda-ku, Tokyo 100 (JP)
- BHP STEEL (JLA) PTY. Ltd.  
Melbourne, Victoria 3000 (AU)

(72) Inventors:

- Fish, John Andrew  
Woonona 2517 NSW (AU)
- Kato, Heiji  
Yokosuka-shi, Kanagawa-ken (JP)

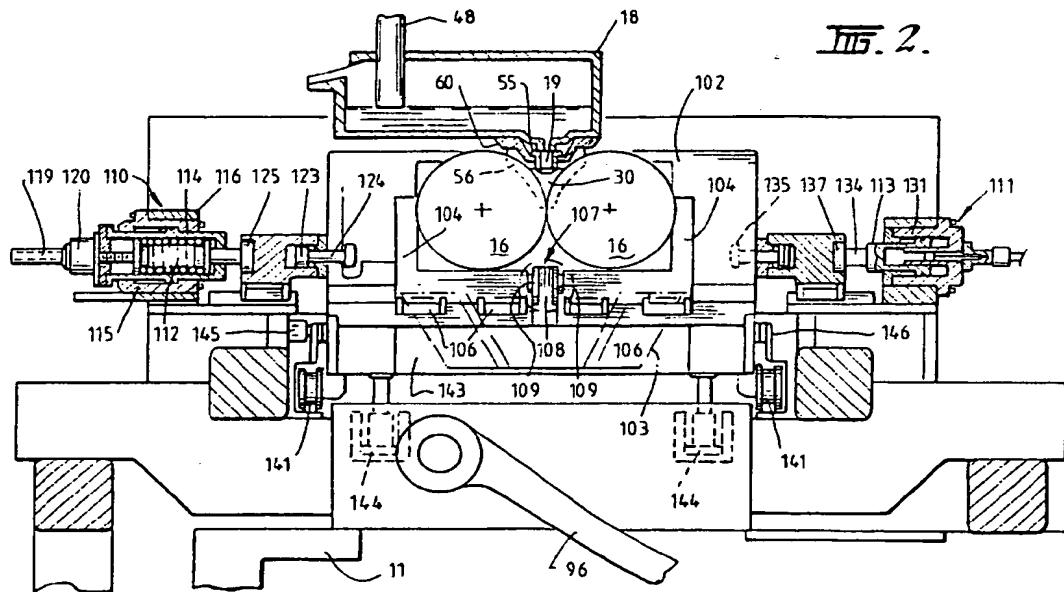
(74) Representative: Lerwill, John et al  
A.A. Thornton & Co.  
Northumberland House  
303-306 High Holborn  
London, WC1V 7LE (GB)

**(54) Strip casting apparatus**

(57) Twin roll caster for casting metal strip. Metal is delivered through a distributor (18) and delivery nozzle (19) between a pair of casting rolls (16) to form a casting pool (30) supported on rolls (16) and confined by end plates (56). Rolls (16) are rotated to deliver cast strip downwardly from the nip between them. Rolls (16) are mounted on carriers (104) moveable to allow rolls (16)

to move bodily toward and away from one another. Biasing units (110, 111) act on the roll carriers (104) to force them against central stops (107) and to provide roll biasing forces.

Stops (107) are adjustable to set the width of the nip between the rolls (16). Biasing units (110) comprise biasing springs (112) whereas biasing units (111) comprise hydraulic actuators (113).



EP 0 903 190 A2

**Description****BACKGROUND OF THE INVENTION**

[0001] This invention relates to the casting of metal strip. It has particular application to the casting of metal strip by continuous casting in a twin roll caster.

[0002] In a twin roll caster molten metal is introduced between a pair of contra-rotated horizontal casting rolls which are cooled so that metal shells solidify on the moving roll surfaces and are brought together at the nip between them to produce a solidified strip product delivered downwardly from the nip between the rolls. The term "nip" is used herein to refer to the general region at which the rolls are closest together. The molten metal may be poured from a ladle into a smaller vessel or series of smaller vessels from which it flows through a metal delivery nozzle located above the nip so as to direct it into the nip between the rolls, so forming a casting pool of molten metal supported on the casting surfaces of the rolls immediately above the nip and extending along the length of the nip. This casting pool is usually confined between side plates or dams held in sliding engagement with end surfaces of the rolls so as to dam the two ends of the casting pool against outflow, although alternative means such as electromagnetic barriers have also been proposed.

[0003] The setting up and adjustment of the casting rolls in a twin roll caster is a significant problem. The rolls must be accurately set to properly define an appropriate width for the nip, generally the order of only a few millimetres, and there must also be some means for allowing at least one of the rolls to move outwardly against a biasing force to accommodate fluctuations in strip thickness particularly during start up. Previously proposed arrangements have employed roll mounting and biasing means in which require relative sliding movement between separate components at several locations, resulting in several sources of friction loading which interferes with accurate positioning of the rolls and accurate measurement of the roll biasing forces. Moreover, with the previous arrangements it has not been possible to provide preloading roll biasing forces which can be accurately set prior to casting and it has been necessary to wait for metal to pass through the rolls to develop reactive forces resisting roll separation in order to generate appropriate roll biasing forces. The present invention provides a novel roll biasing system which minimises the sources of friction during operation and which enables the preloading of the roll biasing forces prior to casting.

**SUMMARY OF THE INVENTION**

[0004] According to the invention there is provided apparatus for continuously casting metal strip comprising a pair of parallel casting rolls forming a nip between them; metal delivery means to deliver molten metal into

the nip between the rolls to form a casting pool of molten metal supported on casting roll surfaces immediately above the nip; pool confining means to confine the molten metal in the casting pool against outflow from the ends of the nip; and roll drive means to drive the casting rolls in counter-rotational directions to produce a solidified strip of metal delivered downwardly from the nip; wherein at least one of the casting rolls is mounted on a pair of moveable roll carriers which allow that one roll

- 5 to move bodily toward and away from the other roll, wherein there is an adjustable stop means to limit inward bodily movement of said one roll toward the other, wherein there is a pair of roll biasing units acting one on each of the pair of moveable roll carriers to bias said one roll bodily inwardly toward the other roll, and wherein each roll biasing unit comprises a thrust transmission structure connected to the respective roll carrier, a thrust reaction structure having a set position, thrust means acting between the thrust reaction structure and the thrust transmission structure to exert a thrust on the thrust transmission structure to bias the respective roll carrier inwardly against the limit imposed by the stop means.
- 10 [0005] Preferably the thrust transmission structure incorporates a load cell to monitor the thrust transmitted thereby without any friction generating movement within that structure.
- 15 [0006] The thrust means may comprise a spring acting between the thrust reaction structure and the thrust transmission structure.
- 20 [0007] Alternatively or in addition the thrust means may comprise a pressure fluid actuator means.
- 25 [0008] If the thrust means consists solely of a pressure fluid actuator means, the thrust reaction structure may be permanently fixed in said set position. However, in the case where the thrust means comprises a spring, the thrust reaction structure may be adjustable in position to vary said set position whereby to vary the biasing force generated by the spring.
- 30 [0009] The casting rolls may each be mounted on a pair of moveable roll carriers so as to be bodily moveable toward and away from the other roll and the adjustable stop means may then limit inward bodily movement of both of the rolls.
- 35 [0010] In that case the said pair of roll biasing units may be one of two such pairs acting on the pairs of roll carriers to bias both of the rolls inwardly against the limit established by the stop means.
- 40 [0011] The adjustable stop means may be disposed beneath the nip and between the roll carriers to serve as a spacer stop for engagement with the roll carriers to pre-set the minimum width of the nip between the rolls and adjustable in width to vary the minimum width of the nip.
- 45 [0012] The roll carriers may comprise a pair of roll end support structures for each of the rolls disposed generally beneath the ends of the respective roll. Each pair of roll end support structures may carry journal bearings

mounting the respective roll ends for rotation about a central roll axis.

[0013] The adjustable stop means may comprise a pair of adjustable stops disposed one between each of the pairs of roll end support structures at the two ends of the roll assembly.

[0014] Each adjustable stop may serve as a centring stop disposed about a central vertical plane through the nip between the rolls and actuatable such that it can be expanded and contracted by equal movements to either side of the central plane so as to maintain equal minimum spacing of the rolls from the central plane.

[0015] Each central stop may be comprised of an expandable and contractible mechanical jack. Each jack may, for example, be screw or worm driven for adjustment.

[0016] The casting rolls and roll carriers may be mounted on a roll module installed in and removable from the caster as a unit. In that case, the thrust transmission structure of each biasing unit may be disconnectable from the respective roll carrier to enable the module to be removed without removing or dismantling the roll biasing units.

[0017] In apparatus in accordance with the invention in which both of the casting rolls are biased by respective pairs of biasing units, the biasing units acting on one of the rolls may have thrust means in the form of springs whereas the biasing units acting on the other roll may have thrust means in the form of pressure fluid actuators whereby the apparatus can be operated in alternative modes in which one of the rolls is restrained against lateral bodily movement and the other is moveable laterally against either spring biasing forces or biasing forces generated by the pressure fluid actuators.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0018] In order that the invention may be fully explained one particular embodiment will be described in some detail with reference to the accompanying drawings in which:

Figure 1 is a vertical cross section through a strip caster constructed in accordance with the present invention.

Figure 2 is an enlargement of part of Figure 1 illustrating important components of the caster.

Figure 3 is a longitudinal cross section through important parts of the caster.

Figure 4 is an end elevation of the caster;

Figures 5, 6 and 7 show the caster in varying conditions during casting and during removal of the roll module from the caster;

Figure 8 is a vertical cross-section through a roll biasing unit incorporating a roll biasing spring; and

Figure 9 is a vertical cross-section through a roll biasing unit incorporating a pressure fluid actuator.

#### DESCRIPTION OF PREFERRED EMBODIMENT

[0019] The illustrated caster comprises a main machine frame 11 which stands up from the factory floor 5 (not shown) and supports a casting roll module in the form of a cassette 13 which can be moved into an operative position in the caster as a unit but can readily be removed when the rolls are to be replaced. Cassette 13 carries a pair of parallel casting rolls 16 to which molten metal is supplied during a casting operation from a ladle (not shown) via a tundish 17, distributor 18 and delivery nozzle 19 to create a casting pool 30. Casting rolls 16 are water cooled so that shells solidify on the moving roll surfaces and are brought together at the nip between them to produce a solidified strip product 20 at the roll outlet. This product may be fed to a standard coiler.

[0020] Casting rolls 16 are contra-rotated through drive shafts 41 from an electric motor and transmission mounted on the main machine frame. The drive shaft 20 can be disconnected from the transmission when the cassette is to be removed. Rolls 16 have copper peripheral walls formed with a series of longitudinally extending and circumferentially spaced water cooling passages supplied with cooling water through the roll ends from

water supply ducts in the roll drive shafts 41 which are connected to water supply hoses 42 through rotary glands 43. The roll may typically be about 500 mm diameter and up to 2000 mm long in order to produce strip product approximately the width of the rolls.

[0021] The ladle is of entirely conventional construction and is supported on a rotating turret whence it can be brought into position over the tundish 17 to fill the tundish. The tundish may be fitted with a sliding gate valve 47 actuatable by a servo cylinder to allow molten metal to flow from the tundish 17 through the valve 47 and refractory shroud 48 into the distributor 18.

[0022] The distributor 18 is also of conventional construction. It is formed as a wide dish made of a refractory material such as magnesium oxide (MgO). One side of the distributor 18 receives molten metal from the tundish 17 and the other side of the distributor 18 is provided with a series of longitudinally spaced metal outlet openings 52. The lower part of the distributor 18 carries mounting brackets 53 for mounting the distributor onto 45 the main caster frame 11 when the cassette is installed in its operative position.

[0023] Delivery nozzle 19 is formed as an elongate body made of a refractory material such as alumina graphite. Its lower part is tapered so as to converge inwardly and downwardly so that it can project into the nip between casting rolls 16. Its upper part is formed with outwardly projecting side flanges 55 which locate on a mounting bracket 60 which forms part of the main frame 11.

[0024] Nozzle 19 may have a series of horizontally spaced generally vertically extending flow passages to produce a suitably low velocity discharge of metal throughout the width of the rolls and to deliver the molten

metal into the nip between the rolls without direct impingement on the roll surfaces at which initial solidification occurs. Alternatively, the nozzle may have a single continuous slot outlet to deliver a low velocity curtain of molten metal directly into the nip between the rolls and/or it may be immersed in the molten metal pool.

[0025] The pool is confined at the ends of the rolls by a pair of side closure plates 56 which are held against stepped ends 57 of the rolls when the roll cassette is in its operative position. Side closure plates 56 are made of a strong refractory material, for example boron nitride, and have scalloped side edges to match the curvature of the stepped ends of the rolls. The side plates can be mounted in plate holders 82 which are movable by actuation of a pair of hydraulic cylinder units 83 to bring the side plates into engagement with the stepped ends of the casting rolls to form end closures for the molten pool of metal formed on the casting rolls during a casting operation.

[0026] During a casting operation the sliding gate valve 47 is actuated to allow molten metal to pour from the tundish 17 to the distributor 18 and through the metal delivery nozzle 19 whence it flows onto the casting rolls. The head end of the strip product 20 is guided by actuation of an apron table 96 to a pinch roll and thence to a coiling station (not shown). Apron table 96 hangs from pivot mountings 97 on the main frame and can be swung toward the pinch roll by actuation of an hydraulic cylinder unit (not shown) after the clean head end has been formed.

[0027] The removable roll cassette 13 is constructed so that the casting rolls 16 can be set up and the nip between them adjusted before the cassette is installed in position in the caster. Moreover when the cassette is installed two pairs of roll biasing units 110, 111 mounted on the main machine frame 11 can be rapidly connected to roll supports on the cassette to provide biasing forces resisting separation of the rolls.

[0028] Roll cassette 13 comprises a large frame 102 which carries the rolls 16 and upper part 103 of the refractory enclosure for enclosing the cast strip below the nip. Rolls 16 are mounted on roll supports 104 which carry roll end bearings (not shown) by which the rolls are mounted for rotation about their longitudinal axis in parallel relationship with one another. The two pairs of roll supports 104 are mounted on the roll cassette frame 102 by means of linear bearings 106 whereby they can slide laterally of the cassette frame to provide for bodily movement of the rolls toward and away from one another thus permitting separation and closing movement between the two parallel rolls.

[0029] Roll cassette frame 102 also carries two adjustable spacers 107 disposed beneath the rolls about a central vertical plane between the rolls and located between the two pairs of roll supports 104 so as to serve as stops limiting inward movement of the two roll supports thereby to define the minimum width of the nip between the rolls. As explained below the roll biasing units

110, 111 are actuatable to move the roll supports inwardly against these central stops but to permit outward springing movement of one of the rolls against preset biasing forces.

5 [0030] Each centralising spacer 107 is in the form of a worm or screw driven jack having a body 108 fixed relative to the central vertical plane of the caster and two ends 109 which can be moved on actuation of the jack equally in opposite directions to permit expansion and contraction of the jack to adjust the width of the nip while maintaining equidistance spacing of the rolls from the central vertical plane of the caster.

10 [0031] The caster is provided with two pairs of roll biasing units 110, 111 connected one pair to the supports 104 of each roll 16. The roll biasing units 110 at one side of the machine are fitted with helical biasing springs 112 to provide biasing forces on the respective roll supports 104 whereas the biasing units 111 at the other side of the machine incorporate hydraulic actuators 113. The 15 detailed construction of the biasing units 110, 111 is illustrated in Figures 8 and 9. The arrangement is such as to provide two separate modes of operation. In the first mode the biasing units 111 are locked to hold the respective roll supports 104 of one roll firmly against the 20 central stops and the other roll is free to move laterally against the action of the biasing springs 112 of the units 110. In the alternative mode of operation the biasing units 110 are locked to hold the respective supports 104 of the other roll firmly against the central stops and the 25 hydraulic actuators 113 of the biasing units 111 are operated to provide servo-controlled hydraulic biasing of the respective roll. For normal casting it is possible to use simple spring biasing but for high productivity casting (60 metres per minute and above) it is most desirable to have servo-controlled biasing forces.

30 [0032] The detailed construction of biasing units 110 is illustrated in Figure 8. As shown in that figure, the biasing unit comprises a spring barrel housing 114 disposed within an outer housing 115 which is fixed to the main caster frame 116 by fixing bolts 117.

35 [0033] Spring housing 114 is formed with a piston 118 which runs within the outer housing 115. Spring housing 114 can be set alternatively in an extended position as illustrated in Figure 8 and a retracted position by flow of hydraulic fluid to and from the cylinder 118. The outer end of spring housing 114 carries a screw jack 119 operated by a geared motor 120 operable to set the position of a spring reaction plunger 121 connected to the screw jack by a rod 130.

40 [0034] The inner end of the spring 112 acts on a thrust rod structure 122 which is connected to the respective roll support 104 through a load cell 125. The thrust structure is initially pulled into firm engagement with the roll support by a connector 124 which can be extended by 45 operation of a hydraulic cylinder 123 when the biasing unit is to be disconnected.

50 [0035] When biasing unit 110 is connected to its respective roll support 104 with the spring housing 114 set

in its extended condition as shown in Figure 8 the position of the spring housing and screw jack is fixed relative to the machine frame and the position of the spring reaction plunger 121 can be set to adjust the compression of the spring 112 and to serve as a fixed abutment against which the spring can react to apply thrusting force to the thrust structure 122 and directly onto the respective roll support 104. With this arrangement the only relative movement during casting operation is the movement of the roll support 104 and thruster structure 122 as a unit against the biasing spring. Accordingly the spring and the load cell are subjected to only one source of friction load and the load actually applied to the roll support can be very accurately measured by the load cell. Moreover, since the biasing unit acts to bias the roll support 104 inwardly against the stop it can be adjusted to preload the roll support with a required spring biasing force before metal actually passes between the casting rolls and that biasing force will be maintained during a subsequent casting operation.

[0036] The detailed construction of biasing units 111 is illustrated in Figure 9. As shown in that figure the hydraulic actuator 113 is formed by an outer housing structure 131 fixed to the machine frame by fixing studs 132 and an inner piston structure 133 which forms part of a thruster structure 134 which acts on the respective roll support 104 through a local cell 137. The thruster structure is initially pulled into firm engagement with the roll support by a connector 135 which can be extended by actuation of a hydraulic piston and cylinder unit 136 when the thruster structure is to be disconnected from the roll support. Hydraulic actuator 113 can be actuated to move the thruster structure 134 between extended and retracted conditions and when in the extended condition to apply a thrust which is transmitted directly to the roll support bearing 104 through the load cell 137. As in the case of the spring biasing units 110, the only movement which occurs during casting is the movement of the roll support and the thruster structure as a unit relative to the remainder of the biasing unit. Accordingly, the hydraulic actuator and the load cell need only act against one source of friction load and the biasing force applied by the unit can be very accurately controlled and measured. As in the case of the spring loaded biasing units, the direct inward biasing of the roll supports against the fixed stop enables preloading of the roll supports with accurately measured biasing forces before casting commences.

[0037] For normal casting the biasing units 111 may be locked to hold the respective roll supports firmly against the central stops simply by applying high pressure fluid to the actuators 113 and the springs 112 of the biasing units 110 may provide the necessary biasing forces on one of the rolls. Alternatively, if the biasing units 111 are to be used to provide servo-controlled biasing forces, the units 110 are locked up by adjusting the positions of the spring reaction plungers 121 to increase the spring forces to a level well in excess of the

roll biasing forces required for normal casting. The springs then hold the respective roll carriers firmly against the central stops during normal casting but provide emergency release of the roll if excessive roll separation forces occur.

5 [0038] Roll cassette frame 102 is supported on four wheels 141 whereby it can be moved to bring it into and out of operative position within the caster. On reaching the operative position the whole frame is lifted by operation of a hoist 143 comprising hydraulic cylinder units 144 and then clamped by operation of horizontal hydraulic cylinder units 145 whereby it is firmly clamped in its operative position. As the cassette frame is raised by operation of the hoist 143 a central centering pin provides accurate longitudinal location of the cassette frame. The operation of the horizontal cylinder units 145 clamps the cassette frame against fixed stops 146 on the main machine frame whereby it is accurately located laterally of the rollers such that the centering jacks or spacers 107 are properly located on the central vertical plane of the caster. This ensures that the rolls are accurately set at equal spacing from the central plane and that the delivery nozzle 19 is also accurately positioned beneath the distributor 18 on the main machine frame

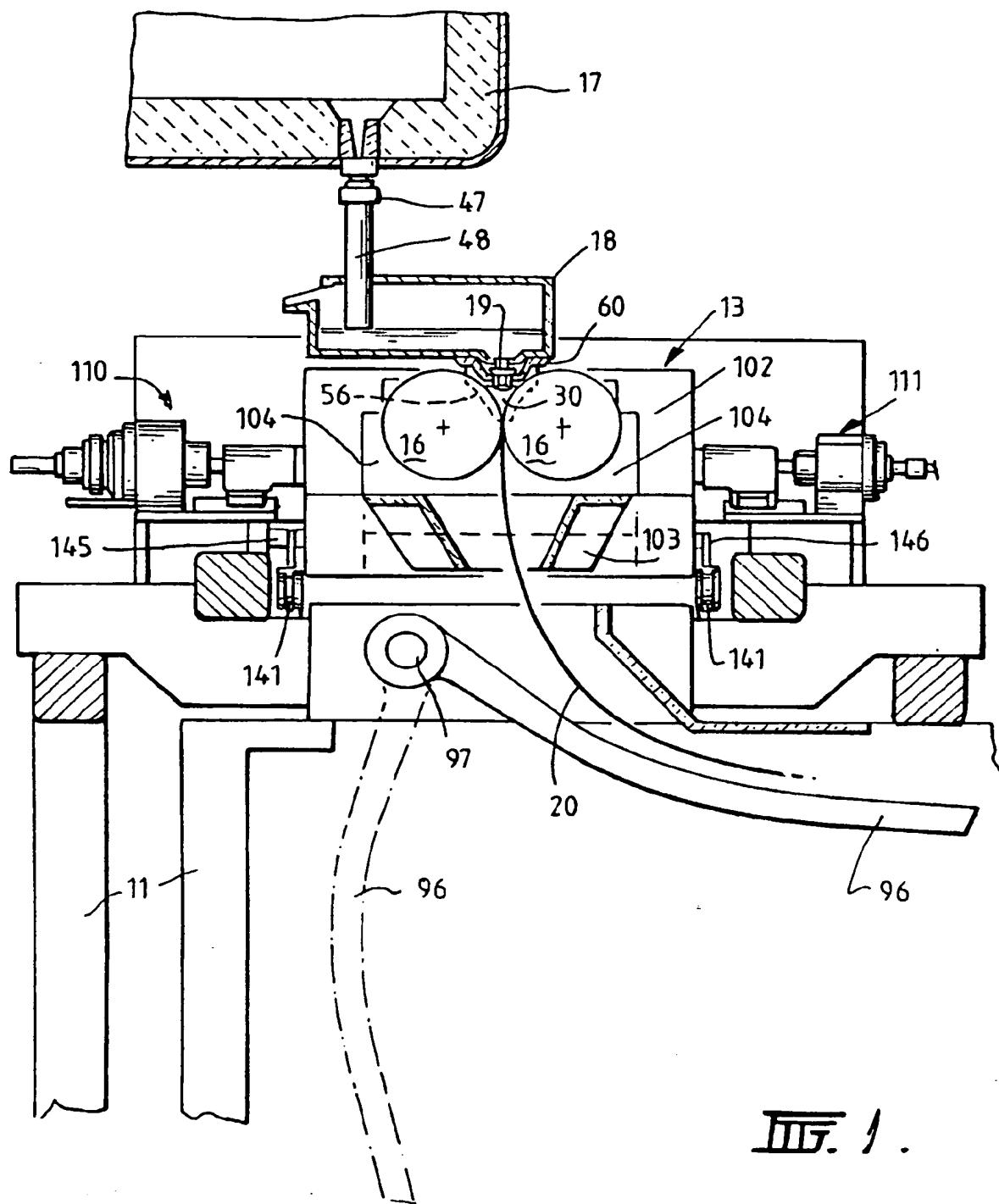
10 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160 165 170 175 180 185 190 195 200 205 210 215 220 225 230 235 240 245 250 255 260 265 270 275 280 285 290 295 300 305 310 315 320 325 330 335 340 345 350 355 360 365 370 375 380 385 390 395 400 405 410 415 420 425 430 435 440 445 450 455 460 465 470 475 480 485 490 495 500 505 510 515 520 525 530 535 540 545 550 555 560 565 570 575 580 585 590 595 600 605 610 615 620 625 630 635 640 645 650 655 660 665 670 675 680 685 690 695 700 705 710 715 720 725 730 735 740 745 750 755 760 765 770 775 780 785 790 795 800 805 810 815 820 825 830 835 840 845 850 855 860 865 870 875 880 885 890 895 900 905 910 915 920 925 930 935 940 945 950 955 960 965 970 975 980 985 990 995 1000 1005 1010 1015 1020 1025 1030 1035 1040 1045 1050 1055 1060 1065 1070 1075 1080 1085 1090 1095 1100 1105 1110 1115 1120 1125 1130 1135 1140 1145 1150 1155 1160 1165 1170 1175 1180 1185 1190 1195 1200 1205 1210 1215 1220 1225 1230 1235 1240 1245 1250 1255 1260 1265 1270 1275 1280 1285 1290 1295 1300 1305 1310 1315 1320 1325 1330 1335 1340 1345 1350 1355 1360 1365 1370 1375 1380 1385 1390 1395 1400 1405 1410 1415 1420 1425 1430 1435 1440 1445 1450 1455 1460 1465 1470 1475 1480 1485 1490 1495 1500 1505 1510 1515 1520 1525 1530 1535 1540 1545 1550 1555 1560 1565 1570 1575 1580 1585 1590 1595 1600 1605 1610 1615 1620 1625 1630 1635 1640 1645 1650 1655 1660 1665 1670 1675 1680 1685 1690 1695 1700 1705 1710 1715 1720 1725 1730 1735 1740 1745 1750 1755 1760 1765 1770 1775 1780 1785 1790 1795 1800 1805 1810 1815 1820 1825 1830 1835 1840 1845 1850 1855 1860 1865 1870 1875 1880 1885 1890 1895 1900 1905 1910 1915 1920 1925 1930 1935 1940 1945 1950 1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070 2075 2080 2085 2090 2095 2100 2105 2110 2115 2120 2125 2130 2135 2140 2145 2150 2155 2160 2165 2170 2175 2180 2185 2190 2195 2200 2205 2210 2215 2220 2225 2230 2235 2240 2245 2250 2255 2260 2265 2270 2275 2280 2285 2290 2295 2300 2305 2310 2315 2320 2325 2330 2335 2340 2345 2350 2355 2360 2365 2370 2375 2380 2385 2390 2395 2400 2405 2410 2415 2420 2425 2430 2435 2440 2445 2450 2455 2460 2465 2470 2475 2480 2485 2490 2495 2500 2505 2510 2515 2520 2525 2530 2535 2540 2545 2550 2555 2560 2565 2570 2575 2580 2585 2590 2595 2600 2605 2610 2615 2620 2625 2630 2635 2640 2645 2650 2655 2660 2665 2670 2675 2680 2685 2690 2695 2700 2705 2710 2715 2720 2725 2730 2735 2740 2745 2750 2755 2760 2765 2770 2775 2780 2785 2790 2795 2800 2805 2810 2815 2820 2825 2830 2835 2840 2845 2850 2855 2860 2865 2870 2875 2880 2885 2890 2895 2900 2905 2910 2915 2920 2925 2930 2935 2940 2945 2950 2955 2960 2965 2970 2975 2980 2985 2990 2995 3000 3005 3010 3015 3020 3025 3030 3035 3040 3045 3050 3055 3060 3065 3070 3075 3080 3085 3090 3095 3100 3105 3110 3115 3120 3125 3130 3135 3140 3145 3150 3155 3160 3165 3170 3175 3180 3185 3190 3195 3200 3205 3210 3215 3220 3225 3230 3235 3240 3245 3250 3255 3260 3265 3270 3275 3280 3285 3290 3295 3300 3305 3310 3315 3320 3325 3330 3335 3340 3345 3350 3355 3360 3365 3370 3375 3380 3385 3390 3395 3400 3405 3410 3415 3420 3425 3430 3435 3440 3445 3450 3455 3460 3465 3470 3475 3480 3485 3490 3495 3500 3505 3510 3515 3520 3525 3530 3535 3540 3545 3550 3555 3560 3565 3570 3575 3580 3585 3590 3595 3600 3605 3610 3615 3620 3625 3630 3635 3640 3645 3650 3655 3660 3665 3670 3675 3680 3685 3690 3695 3700 3705 3710 3715 3720 3725 3730 3735 3740 3745 3750 3755 3760 3765 3770 3775 3780 3785 3790 3795 3800 3805 3810 3815 3820 3825 3830 3835 3840 3845 3850 3855 3860 3865 3870 3875 3880 3885 3890 3895 3900 3905 3910 3915 3920 3925 3930 3935 3940 3945 3950 3955 3960 3965 3970 3975 3980 3985 3990 3995 4000 4005 4010 4015 4020 4025 4030 4035 4040 4045 4050 4055 4060 4065 4070 4075 4080 4085 4090 4095 4100 4105 4110 4115 4120 4125 4130 4135 4140 4145 4150 4155 4160 4165 4170 4175 4180 4185 4190 4195 4200 4205 4210 4215 4220 4225 4230 4235 4240 4245 4250 4255 4260 4265 4270 4275 4280 4285 4290 4295 4300 4305 4310 4315 4320 4325 4330 4335 4340 4345 4350 4355 4360 4365 4370 4375 4380 4385 4390 4395 4400 4405 4410 4415 4420 4425 4430 4435 4440 4445 4450 4455 4460 4465 4470 4475 4480 4485 4490 4495 4500 4505 4510 4515 4520 4525 4530 4535 4540 4545 4550 4555 4560 4565 4570 4575 4580 4585 4590 4595 4600 4605 4610 4615 4620 4625 4630 4635 4640 4645 4650 4655 4660 4665 4670 4675 4680 4685 4690 4695 4700 4705 4710 4715 4720 4725 4730 4735 4740 4745 4750 4755 4760 4765 4770 4775 4780 4785 4790 4795 4800 4805 4810 4815 4820 4825 4830 4835 4840 4845 4850 4855 4860 4865 4870 4875 4880 4885 4890 4895 4900 4905 4910 4915 4920 4925 4930 4935 4940 4945 4950 4955 4960 4965 4970 4975 4980 4985 4990 4995 5000 5005 5010 5015 5020 5025 5030 5035 5040 5045 5050 5055 5060 5065 5070 5075 5080 5085 5090 5095 5100 5105 5110 5115 5120 5125 5130 5135 5140 5145 5150 5155 5160 5165 5170 5175 5180 5185 5190 5195 5200 5205 5210 5215 5220 5225 5230 5235 5240 5245 5250 5255 5260 5265 5270 5275 5280 5285 5290 5295 5300 5305 5310 5315 5320 5325 5330 5335 5340 5345 5350 5355 5360 5365 5370 5375 5380 5385 5390 5395 5400 5405 5410 5415 5420 5425 5430 5435 5440 5445 5450 5455 5460 5465 5470 5475 5480 5485 5490 5495 5500 5505 5510 5515 5520 5525 5530 5535 5540 5545 5550 5555 5560 5565 5570 5575 5580 5585 5590 5595 5600 5605 5610 5615 5620 5625 5630 5635 5640 5645 5650 5655 5660 5665 5670 5675 5680 5685 5690 5695 5700 5705 5710 5715 5720 5725 5730 5735 5740 5745 5750 5755 5760 5765 5770 5775 5780 5785 5790 5795 5800 5805 5810 5815 5820 5825 5830 5835 5840 5845 5850 5855 5860 5865 5870 5875 5880 5885 5890 5895 5900 5905 5910 5915 5920 5925 5930 5935 5940 5945 5950 5955 5960 5965 5970 5975 5980 5985 5990 5995 6000 6005 6010 6015 6020 6025 6030 6035 6040 6045 6050 6055 6060 6065 6070 6075 6080 6085 6090 6095 6100 6105 6110 6115 6120 6125 6130 6135 6140 6145 6150 6155 6160 6165 6170 6175 6180 6185 6190 6195 6200 6205 6210 6215 6220 6225 6230 6235 6240 6245 6250 6255 6260 6265 6270 6275 6280 6285 6290 6295 6300 6305 6310 6315 6320 6325 6330 6335 6340 6345 6350 6355 6360 6365 6370 6375 6380 6385 6390 6395 6400 6405 6410 6415 6420 6425 6430 6435 6440 6445 6450 6455 6460 6465 6470 6475 6480 6485 6490 6495 6500 6505 6510 6515 6520 6525 6530 6535 6540 6545 6550 6555 6560 6565 6570 6575 6580 6585 6590 6595 6600 6605 6610 6615 6620 6625 6630 6635 6640 6645 6650 6655 6660 6665 6670 6675 6680 6685 6690 6695 6700 6705 6710 6715 6720 6725 6730 6735 6740 6745 6750 6755 6760 6765 6770 6775 6780 6785 6790 6795 6800 6805 6810 6815 6820 6825 6830 6835 6840 6845 6850 6855 6860 6865 6870 6875 6880 6885 6890 6895 6900 6905 6910 6915 6920 6925 6930 6935 6940 6945 6950 6955 6960 6965 6970 6975 6980 6985 6990 6995 7000 7005 7010 7015 7020 7025 7030 7035 7040 7045 7050 7055 7060 7065 7070 7075 7080 7085 7090 7095 7100 7105 7110 7115 7120 7125 7130 7135 7140 7145 7150 7155 7160 7165 7170 7175 7180 7185 7190 7195 7200 7205 7210 7215 7220 7225 7230 7235 7240 7245 7250 7255 7260 7265 7270 7275 7280 7285 7290 7295 7300 7305 7310 7315 7320 7325 7330 7335 7340 7345 7350 7355 7360 7365 7370 7375 7380 7385 7390 7395 7400 7405 7410 7415 7420 7425 7430 7435 7440 7445 7450 7455 7460 7465 7470 7475 7480 7485 7490 7495 7500 7505 7510 7515 7520 7525 7530 7535 7540 7545 7550 7555 7560 7565 7570 7575 7580 7585 7590 7595 7600 7605 7610 7615 7620 7625 7630 7635 7640 7645 7650 7655 7660 7665 7670 7675 7680 7685 7690 7695 7700 7705 7710 7715 7720 7725 7730 7735 7740 7745 7750 7755 7760 7765 7770 7775 7780 7785 7790 7795 7800 7805 7810 7815 7820 7825 7830 7835 7840 7845 7850 7855 7860 7865 7870 7875 7880 7885 7890 7895 7900 7905 7910 7915 7920 7925 7930 7935 7940 7945 7950 7955 7960 7965 7970 7975 7980 7985 7990 7995 8000 8005 8010 8015 8020 8025 8030 8035 8040 8045 8050 8055 8060 8065 8070 8075 8080 8085 8090 8095 8100 8105 8110 8115 8120 8125 8130 8135 8140 8145 8150 8155 8160 8165 8170 8175 8180 8185 8190 8195 8200 8205 8210 8215 8220 8225 8230 8235 8240 8245 8250 8255 8260 8265 8270 8275 8280 8285 8290 8295 8300 8305 8310 8315 8320 8325 8330 8335 8340 8345 8350 8355 8360 8365 8370 8375 8380 8385 8390 8395 8400 8405 8410 8415 8420 8425 8430 8435 8440 8445 8450 8455 8460 8465 8470 8475 8480 8485 8490 8495 8500 8505 8510 8515 8520 8525 8530 8535 8540 8545 8550 8555 8560 8565 8570 8575 8580 8585 8590 8595 8600 8605 8610 8615 8620 8625 8630 8635 8640 8645 8650 8655 8660 8665 8670 8675 8680 8685 8690 8695 8700 8705 8710 8715 8720 8725 8730 8735 8740 8745 8750 8755 8760 8765 8770 8775 8780 8785 8790 8795 8800 8805 8810 8815 8820 8825 8830 8835 8840 8845 8850 8855 8860 8865 8870 8875 8880 8885 8890 8895 8900 8905 8910 8915 8920 8925 8930 8935 8940 8945 8950 8955 8960 8965 8970 8975 8980 8985 8990 8995 9000 9005 9010 9015 9020 9025 9030 9035 9040 9045 9050 9055 9060 9065 9070 9075 9080 9085 9090 9095 9100 9105 9110 9115 9120 9125 9130 9135 9140 9145 9150 9155 9160 9165 9170 9175 9180 9185 9190 9195 9200 9205 9210 9215 9220 9225 9230 9235 9240 9245 9250 9255 9260 9265 9270 9275 9280 9285 9290 9295 9300 9305 9310 9315 9320 9325 9330 9335 9340 9345 9350 9355 9360 9365 9370 9375 9380 9385 9390 9395 9400 9405 9410 9415 9420 9425 9430 9435 9440 9445 9450 9455 9460 9465 9470 9475 9480 9485 9490 9495 9500 9505 9510 9515 9520 9525 9530 9535 9540 9545 9550 9555 9560 9565 9570 9575 9580 9585 9590 9595 9600 9605 9610 9615 9620 9625 9630 9635 9640 9645 9650 9655 9660 9665 9670 9675 9680 9685 9690 9695 9700 9705 9710 9715 9720 9725 9730 9735 9740 9745 9750 9755 9760 9765 9770 9775 9780 9785 9790 9795 9800 9805 9810 9815 9820 9825 9830 9835 9840 9845 9850 9855 9860 9865 9870 9875 9880 9885 9890 9895 9900 9905 9910 9915 9920 9925 9930 9935 9940 9945 9950 9955 9960 9965 9970 9975 9980 9985 9990 9995 10000 10005 10010 10015 10020 10025 10030 10035 10040 10045 10050 10055 10060 10065 10070 10075 10080 10085 10090 10095 10100 10105 10110 10115 10120 10125 10130 10135 10140 10145 10150 10155 10160 10165 10170 10175 10180 10185 10190 10195 10200 10205 10210 10215 10220 10225 10230 10235 10240 10245 10250 10255 10260 10265 10270 10275 10280 10285 10290 10295 1030

the other roll (16), there is an adjustable stop means (107) to limit inward bodily movement of said one roll toward the other, there is a pair of roll biasing units (110 or 111) acting one on each of the pair of moveable roll carriers to bias said one roll (16) bodily inwardly toward the other roll (16), and each roll biasing unit (110 or 111) comprises a thrust transmission structure (122 or 134) connected to the respective roll carrier, a thrust reaction structure (121 or 131) having a set position, thrust means (112 or 113) acting between the thrust reaction structure (121 or 131) and the thrust transmission structure (122 or 134) to exert a thrust on the thrust transmission structure to bias the respective roll carrier (104) inwardly against the limit imposed by the stop means (107).

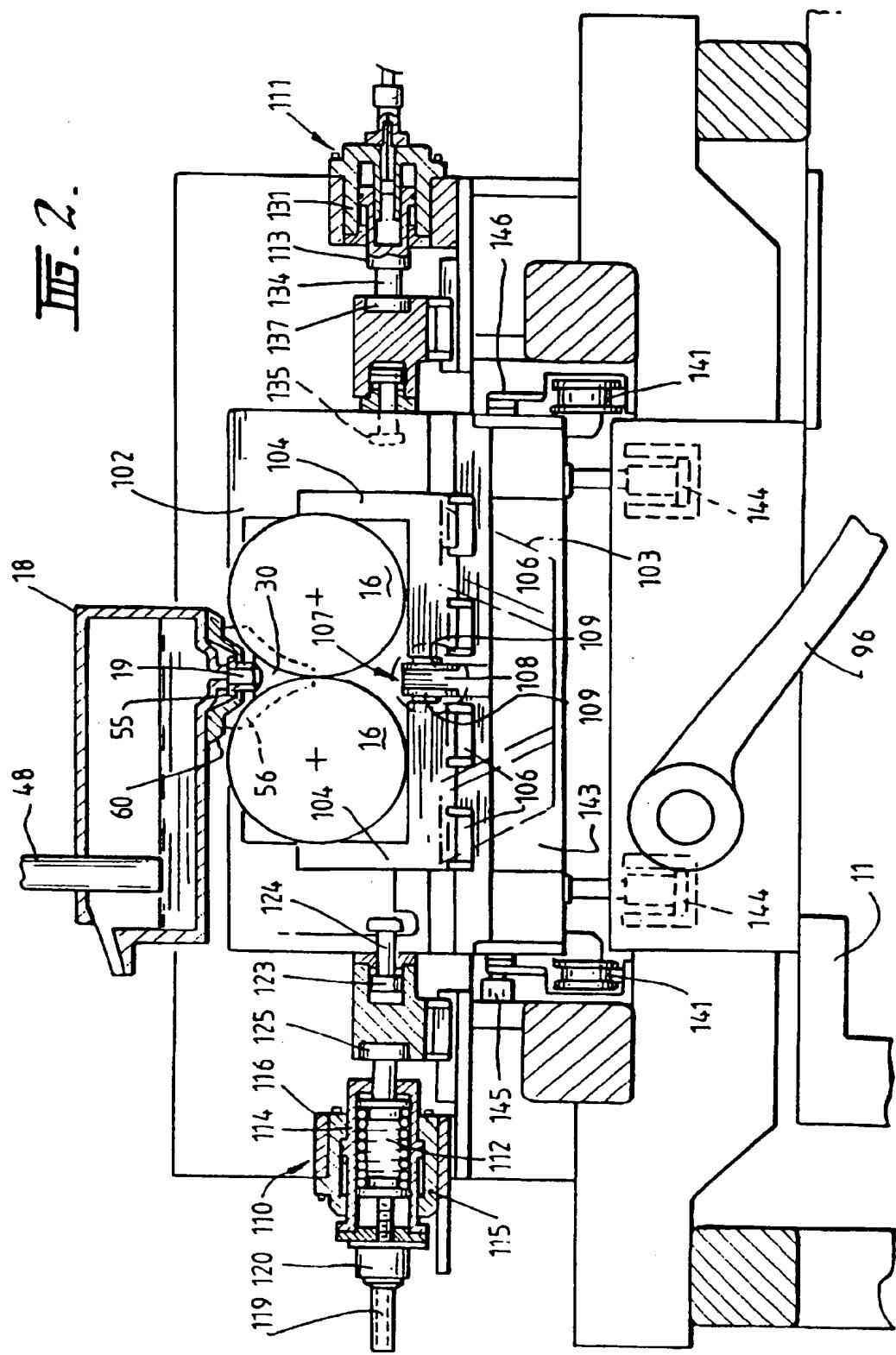
2. Apparatus as claimed in claim 1, further characterised in that the thrust transmission structure (122 or 134) incorporates a load cell (125 or 137) to monitor the thrust transmitted thereby without any friction generating movement within that structure.
3. Apparatus as claimed in claim 1 or claim 2, further characterised in that the thrust means (113) comprises a pressure fluid actuator means.
4. Apparatus as claimed in claim 1 or claim 2, further characterised in that the thrust means (112) comprises a spring acting between the thrust reaction structure (121) and the thrust transmission structure (122).
5. Apparatus as claimed in claim 4, further characterised in that the thrust reaction structure (121) is adjustable in position to vary said set position whereby to vary the biasing force generated by the spring (112).
6. Apparatus as claimed in any one of claims 1 to 5, further characterised in that the casting rolls (16) are each mounted on a pair of movable roll carriers (104) so as to be bodily moveable toward and away from the other roll and the adjustable stop means (107) is effective to limit inward bodily movement of both of the rolls (16).
7. Apparatus as claimed in claim 6, further characterised in that said pair of roll biasing units is one of two such pairs (110, 111) acting on the pairs of roll carriers (104) to bias both of the rolls inwardly against the limit established by the stop means (107).
8. Apparatus as claimed in claim 7, further characterised in that the biasing units (110) acting on one of the rolls (16) have thrust means in the form of springs (112) whereas the biasing units (111) acting

on the other roll (16) have thrust means in the form of pressure fluid actuators (113).

5. Apparatus as claimed in any one of claims 6 to 8, further characterised in that the adjustable stop means (107) is disposed beneath the nip and between the roll carriers (104) to serve as a spacer stop for engagement with the roll carriers (104) to pre-set the minimum width of the nip between the rolls and adjustable in width to vary the minimum width of the nip.
10. Apparatus as claimed in any one of claims 6 to 9, further characterised in that the roll carriers (104) comprise a pair of roll end support structures for each of the rolls disposed generally beneath the ends of the respective roll.
15. Apparatus as claimed in claim 10, further characterised in that each pair of roll end support structures carries journal bearings mounting the respective roll ends for rotation about a central roll axis.
20. Apparatus as claimed in claim 10 or claim 11, further characterised in that the adjustable stop means (107) comprises a pair of adjustable stops disposed one between each of the pairs of roll end support structures at the two ends of the roll assembly.
25. Apparatus as claimed in claim 12, further characterised in that each adjustable stop (107) serves as a centring stop disposed about a central vertical plane through the nip between the rolls and actuatable such that it can be expanded and contracted by equal movements to either side of the central plane so as to maintain equal minimum spacing of the rolls from the central plane.
30. Apparatus as claimed in claim 13, further characterised in that each central stop (107) is comprised of an expandible and contractible mechanical jack.
35. Apparatus as claimed in any one of claims 1 to 14, further characterised in that the casting rolls (16) and roll carriers (104) are mounted on a roll module (13) installed in and removable from the caster as a unit.
40. Apparatus as claimed in claim 15, further characterised in that the thrust transmission structure (122 or 134) of each biasing unit (110 or 111) is discon-nectable from the respective roll carrier (104) to enable the module (13) to be removed without removing or dismantling the roll biasing units.
45. Apparatus as claimed in claim 15, further characterised in that the thrust transmission structure (122 or 134) of each biasing unit (110 or 111) is discon-nectable from the respective roll carrier (104) to enable the module (13) to be removed without removing or dismantling the roll biasing units.
50. Apparatus as claimed in claim 15, further characterised in that the thrust transmission structure (122 or 134) of each biasing unit (110 or 111) is discon-nectable from the respective roll carrier (104) to enable the module (13) to be removed without removing or dismantling the roll biasing units.
55. Apparatus as claimed in claim 15, further characterised in that the thrust transmission structure (122 or 134) of each biasing unit (110 or 111) is discon-nectable from the respective roll carrier (104) to enable the module (13) to be removed without removing or dismantling the roll biasing units.



III. 1.



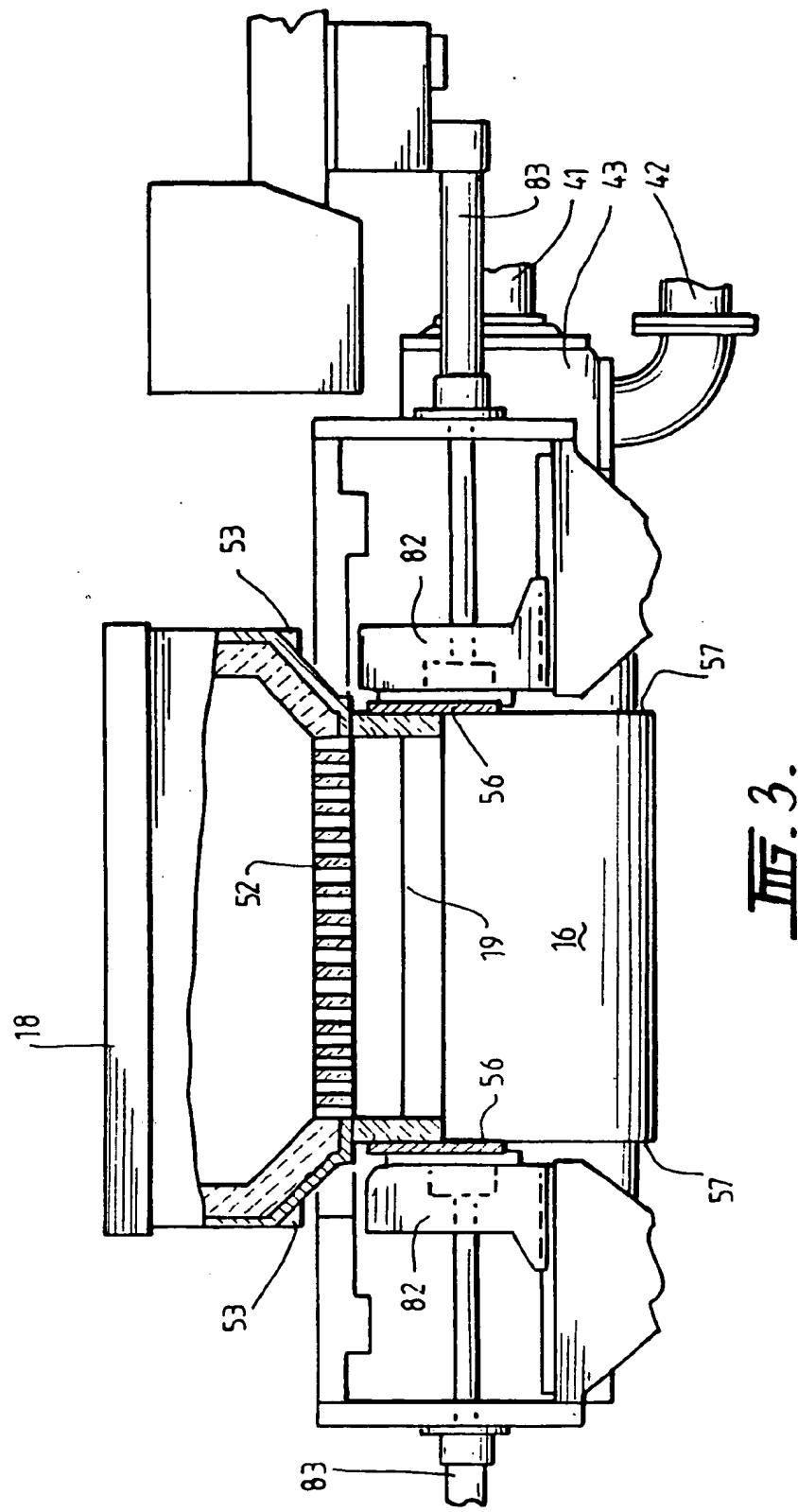
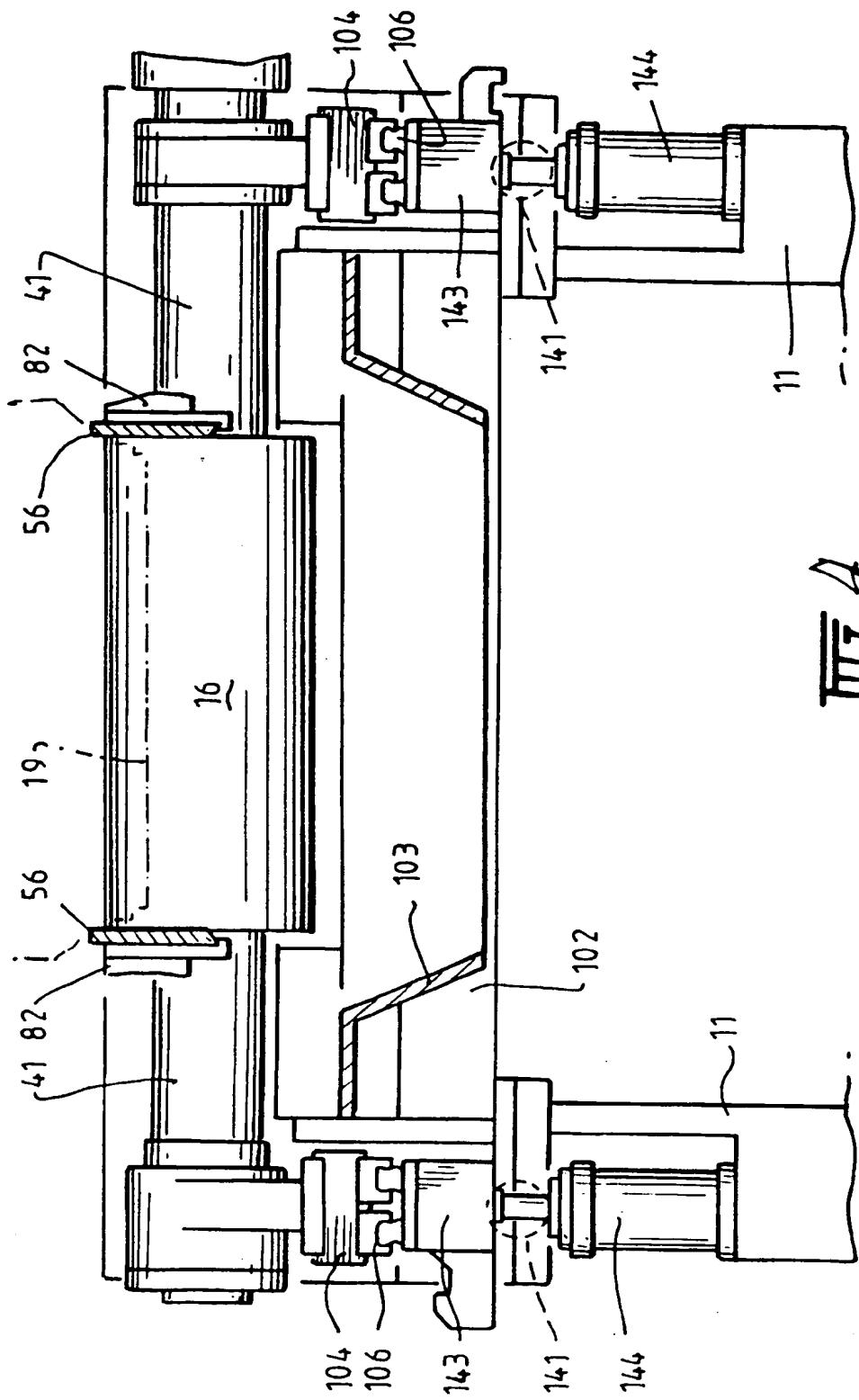
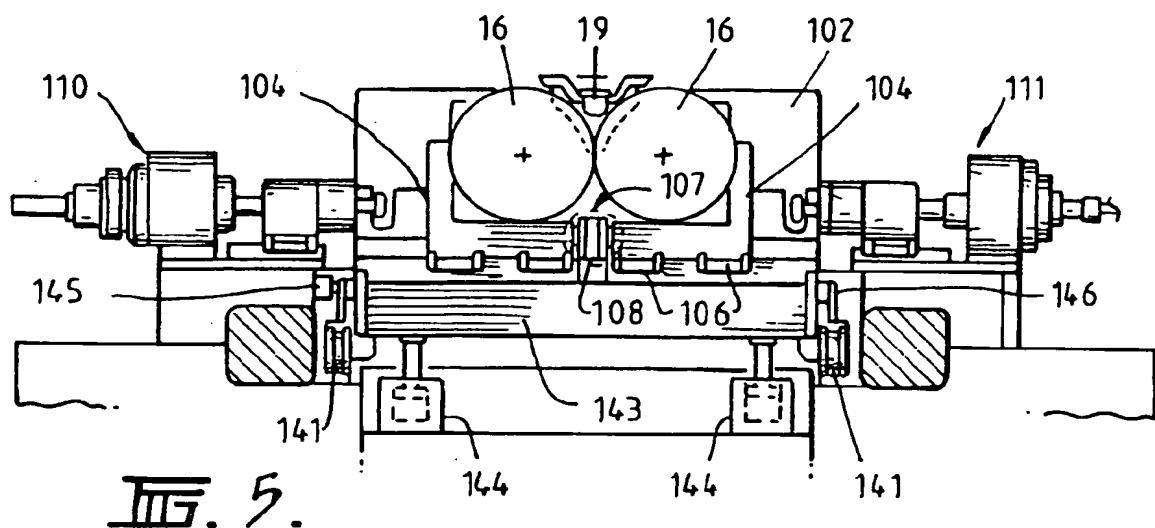
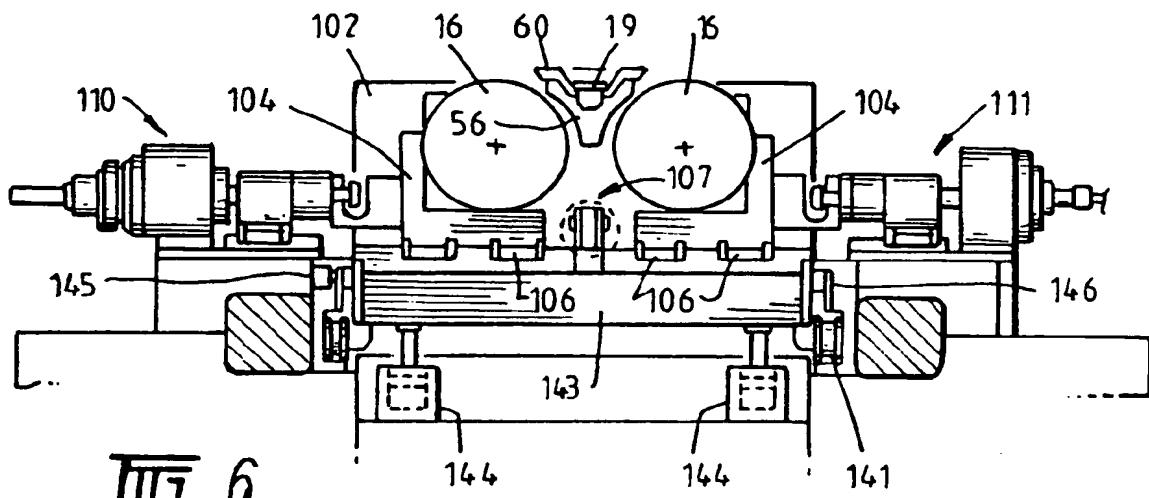


FIG. 3.

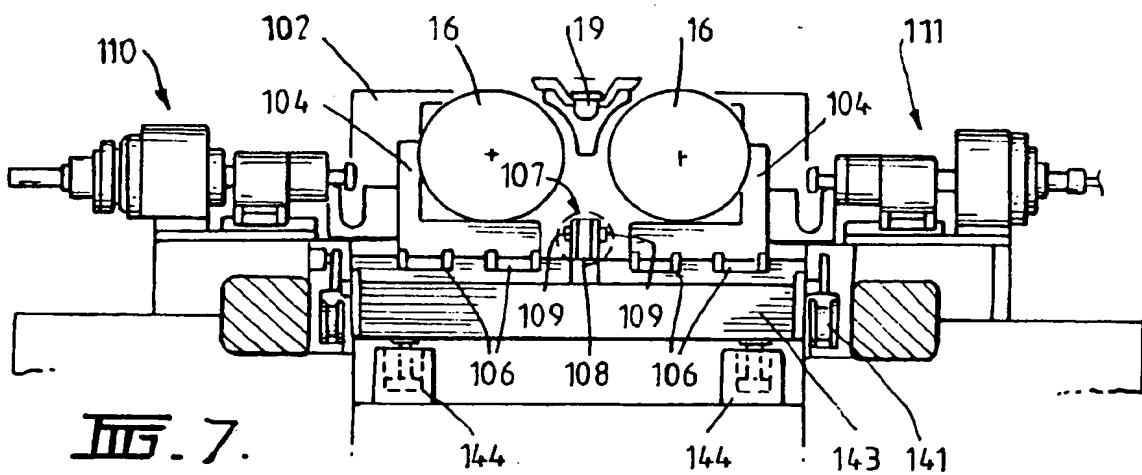




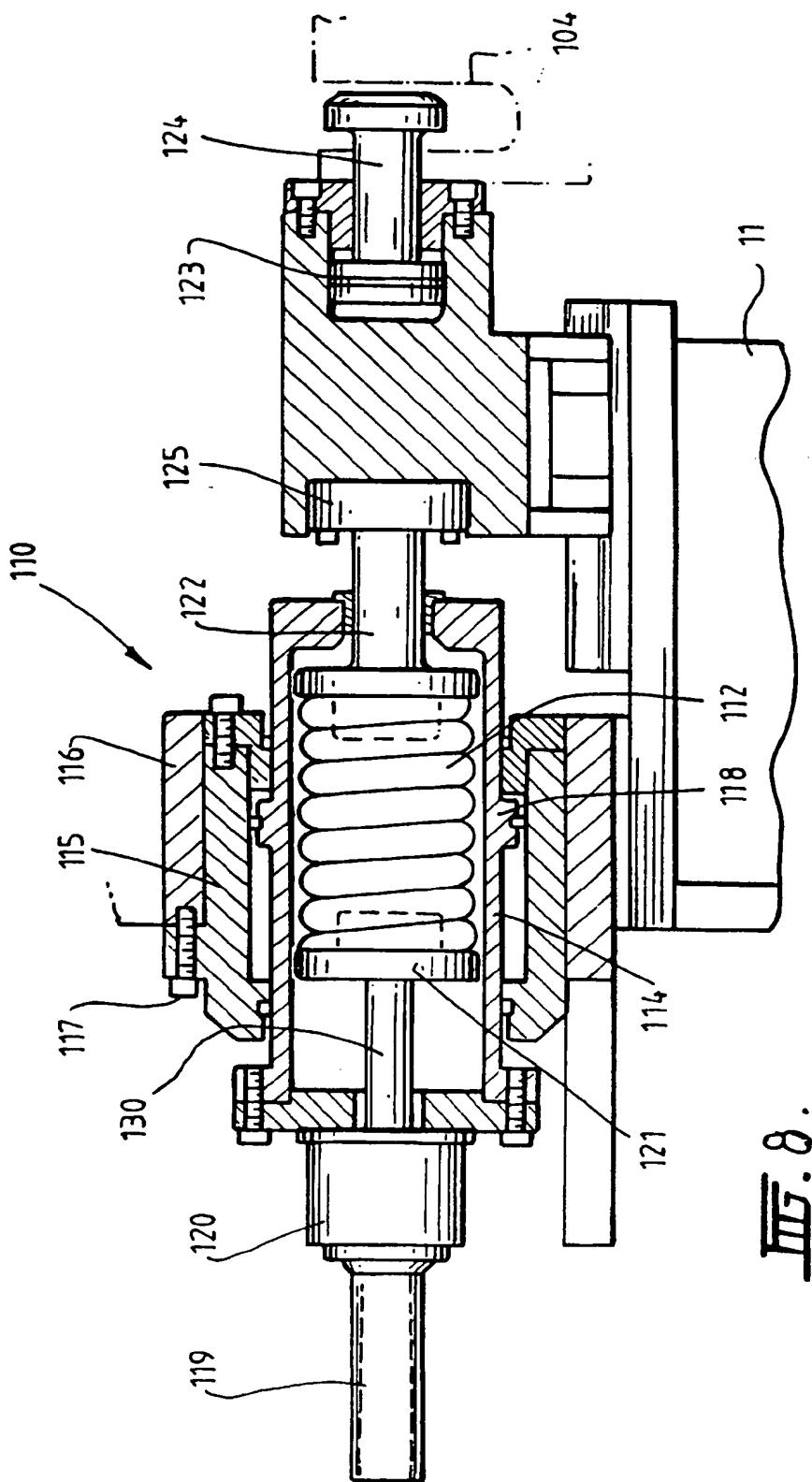
五. 5.



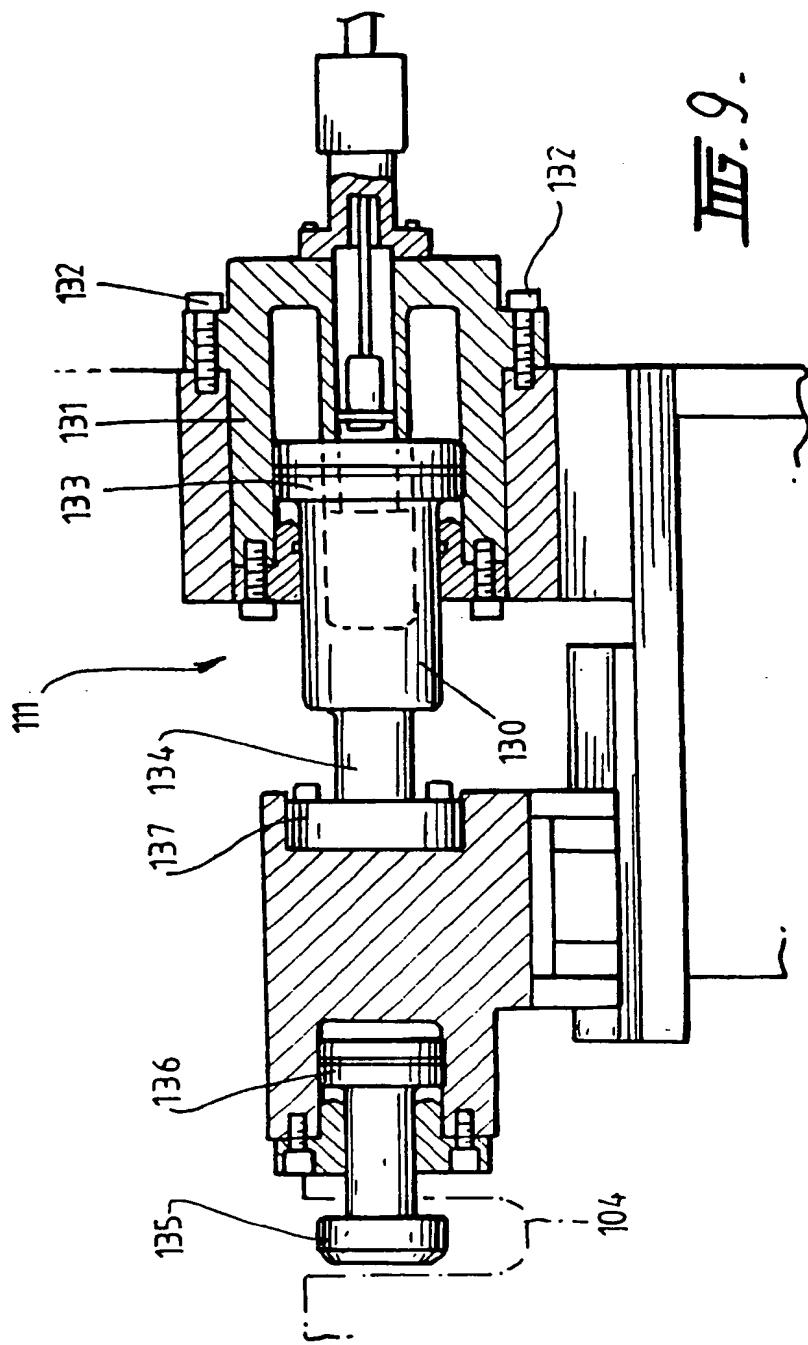
五. 6.



五.7.



III. 9.



(19)



Europäisches Patentamt  
European Patent Office  
Office européen des brevets

(11)

EP 0 903 190 A3

(12)

## EUROPEAN PATENT APPLICATION

(88) Date of publication A3:  
10.01.2001 Bulletin 2001/02

(51) Int Cl. 7: B22D 11/06

(43) Date of publication A2:  
24.03.1999 Bulletin 1999/12

(21) Application number: 98307241.4

(22) Date of filing: 08.09.1998

(84) Designated Contracting States:  
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU  
MC NL PT SE

Designated Extension States:  
AL LT LV MK RO SI

(30) Priority: 18.09.1997 AU PO925397  
30.09.1997 AU PO952297

(71) Applicants:  
• Ishikawajima-Harima Heavy Industries Co., Ltd.  
Chiyoda-ku, Tokyo 100 (JP)

• BHP STEEL (JLA) PTY. Ltd.  
Melbourne, Victoria 3000 (AU)

(72) Inventors:

• Fish, John Andrew  
Woonona 2517 NSW (AU)  
• Kato, Heiji  
Yokosuka-shi, Kanagawa-ken (JP)

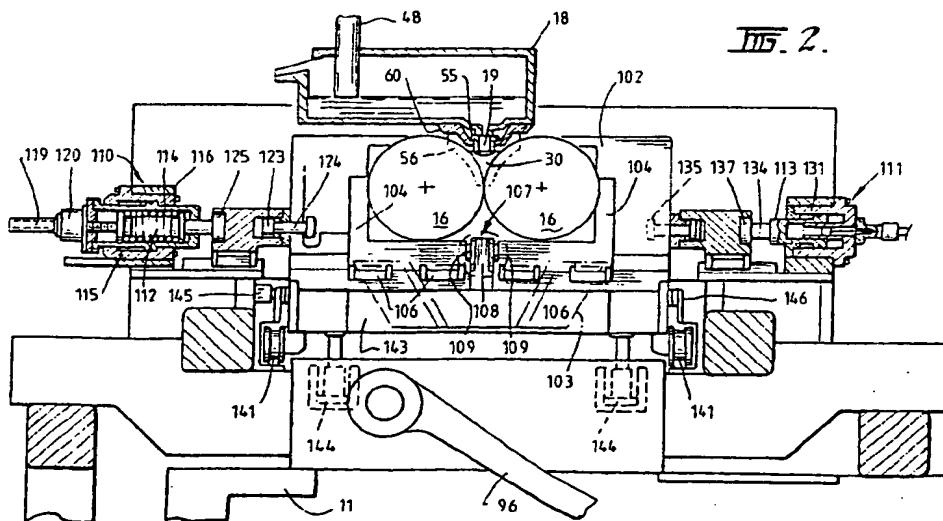
(74) Representative: Lerwill, John et al  
A.A. Thornton & Co.  
235 High Holborn  
London, WC1V 7LE (GB)

### (54) Strip casting apparatus

(57) Twin roll caster for casting metal strip. Metal is delivered through a distributor (18) and delivery nozzle (19) between a pair of casting rolls (16) to form a casting pool (30) supported on rolls (16) and confined by end plates (56). Rolls (16) are rotated to deliver cast strip downwardly from the nip between them. Rolls (16) are mounted on carriers (104) moveable to allow rolls (16)

to move bodily toward and away from one another. Biasing units (110, 111) act on the roll carriers (104) to force them against central stops (107) and to provide roll biasing forces.

Stops (107) are adjustable to set the width of the nip between the rolls (16). Biasing units (110) comprise biasing springs (112) whereas biasing units (111) comprise hydraulic actuators (113).





European Patent  
Office

## EUROPEAN SEARCH REPORT

Application Number

EP 98 30 7241

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
A	EP 0 450 775 B (LYSAGHT AUSTRALIA LTD ;ISHIKAWAJIMA HARIMA HEAVY IND (JP)) 9 October 1991 (1991-10-09) * claims 1,14-17 *	1-16	B22D11/06
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			B22D
	The present search report has been drawn up for all claims		
Place of search	Date of completion of the search	Examiner	
BERLIN	21 November 2000	Kesten, W	
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons S : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 98 30 7241

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

21-11-2000

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
EP 0450775	B 09-10-1991	AT	153573 T	15-06-1997
		AU	631728 B	03-12-1992
		AU	7289791 A	10-10-1991
		BR	9101329 A	26-11-1991
		CA	2039662 A	05-10-1991
		CN	1055311 A, B	16-10-1991
		DE	69126229 D	03-07-1997
		DK	450775 T	30-06-1997
		EP	0450775 A	09-10-1991
		ES	2103775 T	01-10-1997
		GR	3024486 T	28-11-1997
		JP	6339753 A	13-12-1994
		KR	210519 B	15-07-1999
		NZ	237557 A	23-12-1992
		US	5184668 A	09-02-1993
		US	5277243 A	11-01-1994

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82